UPPER HUMBER RIVER

PERMISSIBLE WASTE LOADINGS FROM ADDITIONAL URBAN DEVELOPMENT BASED ON WATER QUALITY CONSIDERATIONS

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1976

Technical Support Section

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SUMMARY AND CONCLUSIONS

The upper watershed of the Humber, as well as the East Humber River, are favourably low in oxygen consuming materials and the levels of dissolved oxygen are satisfactory. In general, the water quality is considered adequate. While the East Humber has a higher mineral content than the Humber River, the latter contains higher nutrients and bacteria which are the products of development within this basin.

At the present time, there is some need for concern primarily over two water-quality parameters - 1) pathogenic bacteria and 2) chlorine. It would appear that bacterial levels in both the Humber and East Humber slightly exceed the Ministry of Environment's criteria for body contact recreation. However, as existing bacterial levels should not pose a health hazard, and as the sources of these bacteria likely do not relate to human wastes and would be difficult to identify, a major study to further evaluate this minor problem is not presently warranted. Regarding chlorine, it is expected that levels of total residual chlorine downstream from Bolton are presently at levels which cause minimal disruption to the biological community.

Regarding the impact of waste discharges from expanding urbanized areas, it is suggested that with dechlorination facilities at the Bolton and Kleinburg sewage treatment facilities, loadings of organics (BOD) would be of greatest concern. With effluent discharges containing 10 mg/l BOD_5, the hydraulic S.T.P. discharge at Bolton should not exceed 1.1 MIGD (110 lb. BOD_5/day), which would be equivalent to a population of 11,000 people (assuming 100 IG per person per day). This BOD_5 limitation would be more restrictive than would be nitrate, assuming a nitrate discharge concentration of 20 mg/l as N.

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The river at Kleinburg, downstream of the proposed Nashville reservoir, can withstand an organic loading of approximately 210 lbs of BOD_5 per day. This would be equivalent to a population of approximately 21,000 people, assuming a hydraulic loading of 2.1 MIGD and a final treatment plant effluent of 10 mg/l BOD_5. With respect to nitrate, it is thought that the receiving capacity of the river, without nitrogen removal at the S.T.P., would be reached at approximately the same time (with respect to population) as would the receiving capacity for BOD_5.

The monitoring of the river would determine any changes in the nitrogen concentration associated with urbanization so that the nitrogen impact on the river will be under constant review.

Any future sewage treatment facility at Nobleton should not discharge to the East Humber River, but instead should discharge to the Humber River below the Nashville reservoir site.

In order to minimize future problems in the Upper Humber River Basin, the following recommendations are made with respect to waste discharges to the streams.

RECOMMENDATIONS

1. The minimum level of treatment for sewage treatment plants discharging continuously to the Humber River watershed should incorporate secondary treatment with phosphorus removal and effluent filtration.

2. The average concentrations of BOD_5 in the Humber River, during low flow periods, should not exceed 3 mg/l between Bolton and the proposed Nashville Reservoir, and 4 mg/l downstream of the proposed Reservoir.

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3. For assimilation calculations at Bolton, the values used for streamflow and upstream BOD_5 should be the $7Q_{20}$ of 10 cfs, and 0.9 mg/l respectively. The organic (BOD) loadings to the River from the Bolton sewage treatment facility should not exceed 110 lb. BOD_5/day, assuming an effluent BOD_5 concentration of 10 mg/l.

4. The level of total residual chlorine in the Humber River should not exceed 0.01 mg/l. For design purposes, the $7Q_{20}$ of the River should again be used in determining the chlorine concentration of the effluent discharging into the river.

5. In order to minimize enrichment of the Humber River, future sewage treatment plants and expansions of existing facilities should be designed to produce a maximum phosphorus concentration of 0.5 mg/l in the effluent.

6. The nitrogen equivalent (i.e. nitrite, nitrate, ammonia and Kjeldahl nitrogen) in the River should not exceed 7.5 mg/l under $7Q_{20}$ river flow conditions.

7. The effluent from any future Nobleton sewage treatment facility should be discharged to the Humber River downstream of the proposed Nashville Reservoir rather than to the East Humber River.

8. Unless the Nobleton sewage treatment system can be designed to discharge in spring and fall at a rate not exceeding 7-8 cfs (based on an effluent BOD_5 of 15 mg/l), a continuous discharge mechanical plant, with effluent filtration and phosphorus removal, should be employed as a sewage treatment facility. With respect to organic loadings to the Humber River in the vicinity of Kleinburg (reach proposed Nashville Control Dam to

Kleinburg) the river can adequately assimilate a continuous loading of 210 lb BOD_5/day from sewage treatment plants at Nobleton plus Kleinburg discharging an effluent quality of 10 mg/l BOD_5.

9. Municipalities in the Upper Humber Watershed should initiate plans for the control and treatment of urban storm water run-off.

10. The planning and design of new subdivisions should incorporate storm-water treatment and control to minimize the impact of the development on the flow regime and water quality of the streams.

INTRODUCTION

The purpose of this study was to investigate the existing water quality of the Humber River and East Humber rivers and to determine permissible treated sewage loadings from Bolton, Kleinburg and Nobleton on the flow regime and resulting water quality of these rivers. The permissible sewage flows were mainly based on four parameters, namely dissolved oxygen (D.O.), biochemical oxygen demand primarily by organic material over a five day period (BOD_5), nitrogen concentrations as available in nitrates, nitrites, free ammonia and Kjeldahl nitrogen, and chlorine concentrations both in the effluent and receiving river.

The treatment plant at Bolton has been designed to produce a high quality effluent, with a BOD_5 of 10 mg/l or less, and a maximum total phosphorus of 1.0 mg/l.

The community of Kleinburg, located approximately four miles downstream of Bolton, has a secondary treatment plant, 0.05 MIGD capacity, which also discharges to the Humber River (Figure 1). The Ministry of the Environment advised the Regional Municipality of York in September, 1974, that this plant could be expanded to accommodate a population of approximately 2700 people provided that treatment at the Kleinburg plant included phosphorus removal and effluent filtration.

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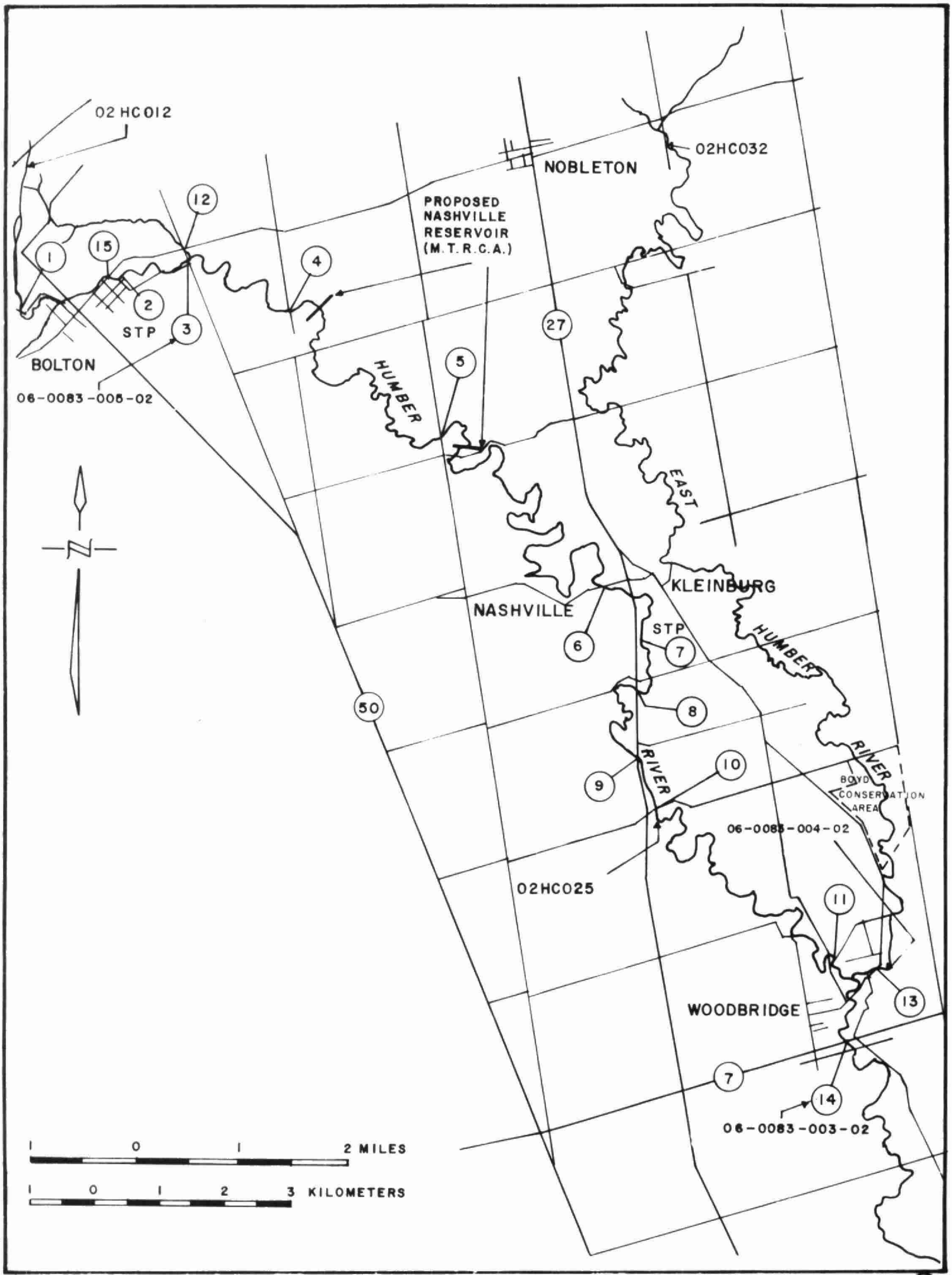

FIGURE 1: THE STUDY AREA, ILLUSTRATING SAMPLING STATIONS (eg. ⑨) LONG-TERM MONITORING STATIONS (eg. 06-0063-003-02), FLOW GAUGING STATIONS (eg. 02HC025), AS WELL AS URBAN AREAS, SEWAGE TREATMENT PLANT LOCATIONS

Nobleton, which is located on the watershed of the East Humber River, has an approximate population of 1800 persons. The community is serviced by septic tank tile field systems. This method of treatment is reportedly inadequate due to poor soil conditions, causing flooding, resulting in discharges to roadside ditches and storm drains (1). It is therefore likely that in the future, Nobleton should be serviced with a communal sewerage system, possibly with a discharge to the Humber River. Nobleton may be capable of supporting a maximum population of 8000 persons utilizing local ground waters (1), provided acceptable sewage treatment facilities and a wastewater receiver are available.

STREAMFLOW

The streamflow of the Humber River is typical of the flows in the southern Ontario streams with high flows during spring freshets, after heavy rainfalls and mid winter snow melts to low flows during late summer, early fall, and mid winter periods and extremely low flows during extended drought periods. This is reflected by a typical annual hydrograph of the Humber River at Elder Mills gauge as shown in Appendix 1.

Streamflow records are available of the Humber and East Humber rivers at several gauging station locations. The table below summarizes pertinent information about the gauging stations for which continuous flow dates are available, and that lie within the study area.

Summary of Streamflow Gauging Stations, Upper Humber River Basin as of January 1976

(location of stations are shown in Figure 1)

Station Name	Station Number	Drainage Area (sq. mi.)	Period of Continuous Record	Type of Gauge
Humber River at Cedar Mills	02HC012	65.2	1957-64 1965-75	Manual Recording
Humber River at Elder Mills	02HC025	117	1962-75	Recording
East Humber River at Humber Trails	02HC032	36.6	1965-75	Recording

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The low flow characteristics of streams that are receiving and assimilating waste from sewage treatment plants or are considered for such purposes are of special interest especially if such waste loadings are continuous. As the Humber river is presently receiving sewage wastes from Bolton and Kleinburg and further expansion of waste loading is under review, the low flow characteristics of the Humber and East Humber rivers were evaluated.

Analyses were conducted on the frequency of annual low flows, based on the lowest average seven day flows for the rivers at the gauging stations referred to above. Frequency curves on these low flows are presented in Appendices II, III, and IV, and the results are summarized below:

Low Flow Characteristics, Humber and East Humber Rivers at Indicated Stream Gauging Stations for Selected Recurrence Intervals

River and Location	Minimum Annual Seven-Day Flows at Selected Recurrence Intervals							
	Most Probable		5-Year		10-Year		20-Year	
	cfs	mgd	cfs	mgd	cfs	mgd	cfs	mgd
Humber River at Cedar Mills	28.0	15.1	12.5	6.75	10.2	5.51	8.5	4.59
Humber River at Elder Mills	31.0	16.7	23.5	12.7	20.5	11.1	18.0	9.72
East Humber River at Humber Trail	2.2	1.19	1.9	1.03	1.8	0.97	1.6	0.86

Streamflows on both the Humber and East Humber rivers are not manipulated by means of control works constructed on these rivers within the study area. However, the Metropolitan Toronto and Region Conservation Authority proposes the construction of two reservoirs on the Humber River, namely the Bolton Reservoir upstream of Bolton and the Nashville Reservoir upstream of Kleinburg. The operation of these reservoirs could alter the streamflows downstream of these reservoirs significantly and would likely increase the low flows presently experienced in the Humber River. As no final approval has been given by the Provincial Government for their construction their future effects on streamflow were not quantified.

Streamflow analyses were also carried out, for the gauging stations at Elder Mills and Humber Trail, with the assumption that there may be a proposal for a seasonal discharge from a future Nobleton sewage treatment facility. Figures 2 and 3 illustrate spring and fall flow data for the two stations. In addition, the following table illustrates the lowest average seven day spring (April-May) and fall (October-November) flows for various recurrence intervals.

Low Flow Characteristics, Humber and East Humber Rivers at Indicated Stream Gauging Stations for Selected Recurrence Intervals, for Spring (April-May) and Fall (October-November) Periods

River, Location, Time of Year	Minimum Seven-Day Flows at Selected Recurrence Intervals							
	Most Probable		5-Year		10-Year		20-Year	
	cfs	mgd	cfs	mgd	cfs	mgd	cfs	mgd
Humber River at Elder Mills								
-spring	67	36	46	25	42	23	38	20
-fall	41	22	30	16	29	16	28	15
East Humber at Humber Trail								
-spring	10	5.4	5.8	3.1	5.0	2.7	4.7	2.5
-fall	3.1	1.7	2.3	1.2	2.0	1.1	1.8	0.9

SCOPE OF FIELD SURVEY

On June 24, 1974, and August 12, 1975, a 24 hour "intensive" sampling program was carried out on the Humber River from Bolton downstream to the upper limits of the community of Woodbridge, a distance of approximately 19.3 stream miles. A total of 12 stations (numbers 1-12) were sampled in 1974, and 15 stations in 1975 (see Figure 1). Two of the stations in both surveys were the Bolton and Kleinburg S.T.P. outfalls. During each sampling run, samples and measurements were obtained at each station approximately every 4 hours over a

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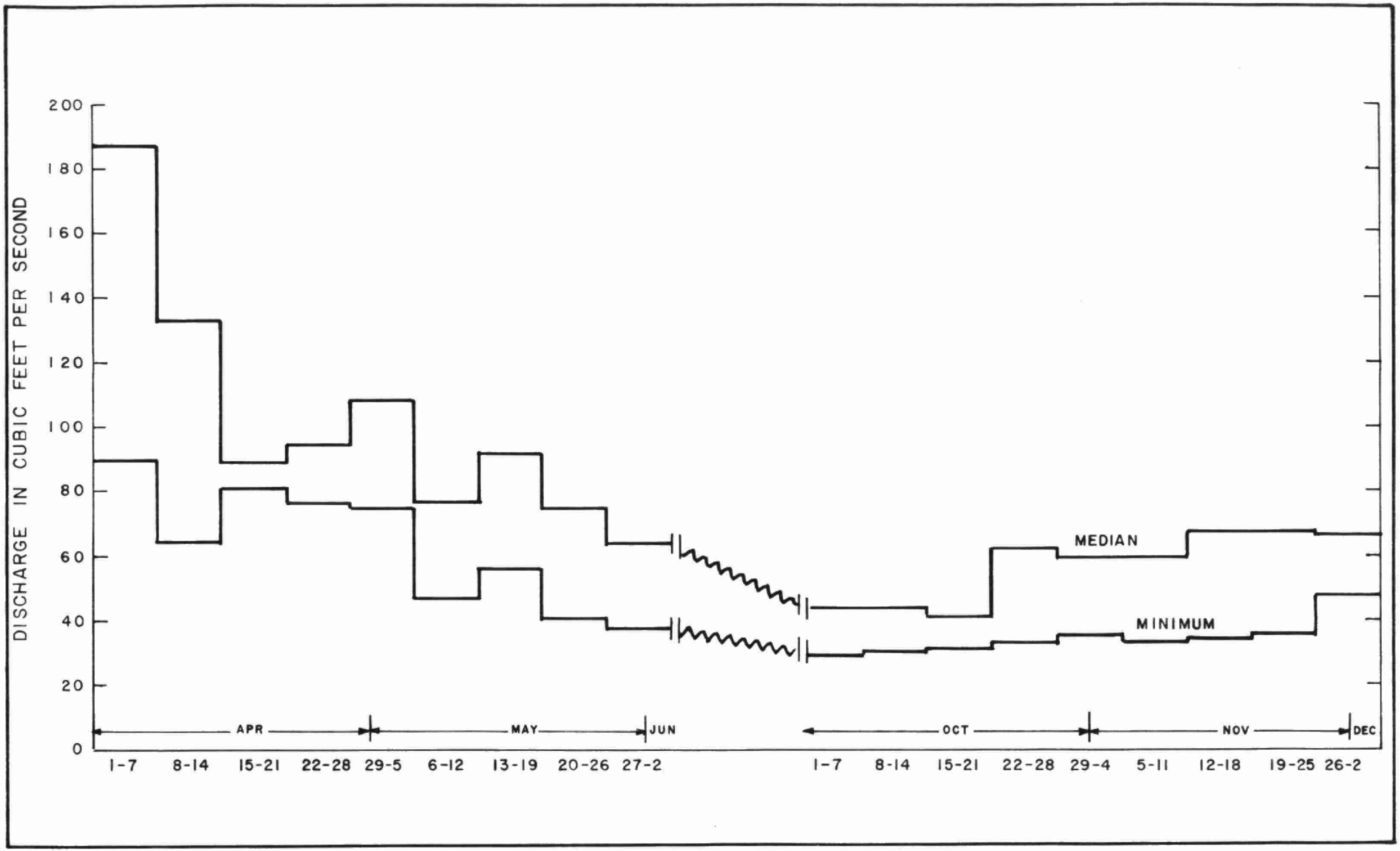

FIGURE 2: STREAM FLOWS FOR APRIL – MAY AND OCTOBER – NOVEMBER FOR STATION 02HC025 ON THE HUMBER RIVER AT ELDER MILLS. PERIOD OF RECORD : 1962 – 1973

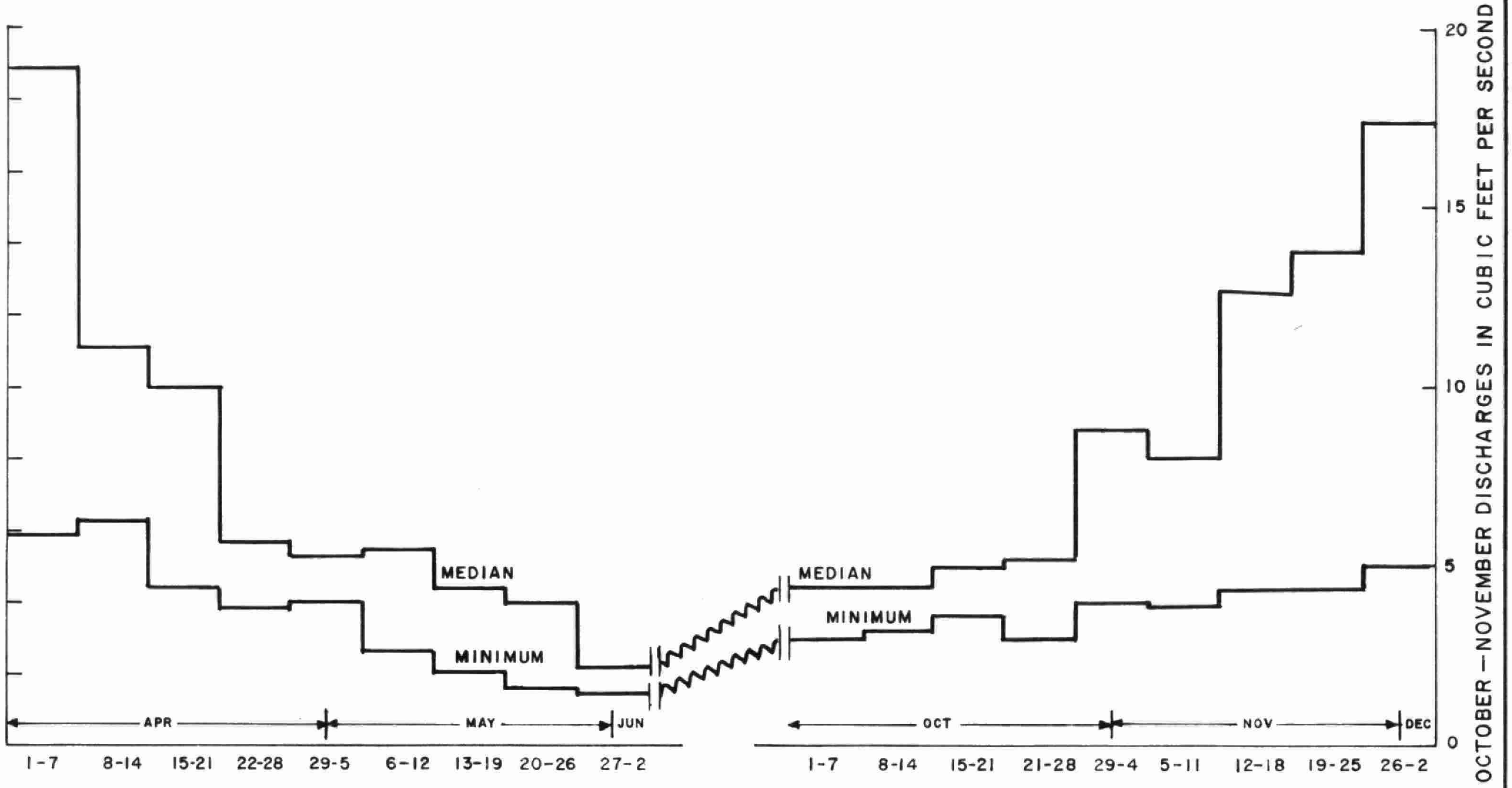

FIGURE 3: STREAM FLOWS FOR APRIL – MAY AND OCTOBER – NOVEMBER FOR STATION 02HC032 ON THE EAST HUMBER RIVER AT KLEINBURG. PERIOD OF RECORD: 1965 – 1973

24-hour period. Chemical samples were analyzed at the Ministry of the Environment laboratory for BOD_5, total and soluble phosphorus, free ammonia, total Kjeldahl nitrogen, nitrite, nitrate, turbidity (1974 only), chloride, conductivity and total and suspended solids. In-situ measurements for dissolved oxygen and temperature were carried out, and bacteriological samples were collected for analyses of total and fecal coliforms as well as fecal streptococci.

During the 1974 intensive survey, streamflow measurements were made at three locations just above the Bolton S.T.P. discharge, and at stations 6 and 12. Also, the readings at the Federal flow gauge #02HC025 (Figure 1) were recorded on each sampling run during both the 1974 and 1975 intensive surveys.

In addition to the above sampling programs, monitoring runs were carried out at the same 15 locations on June 5, July 10 and August 1, 1975.

SURVEY FINDINGS

Streamflow

The streamflow of the Humber River at Elder Mills during the 1974 intensive survey on June 24, averaged 49.9 cfs; during the 1975 intensive survey on August 12, the flows averaged 23.2 cfs and varied from 17.0 cfs to 26.0 cfs. These flows compare favourable with the minimum average seven day flow at a recurrence interval of 1 in 20 years or $7Q_{20}$ of 18.0 cfs at this location. The flows during the 1975 intensive study approached the low flow conditions exemplified by the $7Q_{20}$.

The locations measured for streamflow on June 24, 1975, revealed flows of 36 cfs just upstream of the Bolton S.T.P., 49 cfs at station 6, and 11.5 cfs at station 12.

Water Quality

A. 1974 Intensive Study

Appendix V illustrates the water quality data collected during the 1974 "intensive" study.

In general, water quality in the study area was acceptable. Levels of dissolved oxygen were excellent, ranging from a low measurement of 8.2 mg/l, to a hight of 11.4 mg/l.

Similarly, levels of BOD_5 in the stream were favourably low, ranging from a low measurement of 0.4 mg/l, to a high of 1.8 mg/l.

The only data which indicated the need for some concern were as follows:

a) The level of dissolved oxygen in the Kleinburg S.T.P. effluent was low (2.8 mg/l average). However, this level had no detectable affect on dissolved oxygen in the stream due largely to the large dilution provided by the River during the study.

b) The effluent from the Kleinburg S.T.P. increased the phosphorus level in the stream from an average of 0.10 mg/l (station 6) to an average of 0.18 mg/l (station 8). It should be noted, however, that the dissolved oxygen data revealed no effect of this increased phosphorus on the level of photosynthesis in the stream.

c) While the pathogenic - indicating bacteria should not be directly related to the Ministry's body contact recreational criteria because of a lack of sampling frequency, it would appear that the average levels in the study area would likely have exceeded the criteria. As the stream quality data cannot be related directly to the two S.T.P. effluents, it appears that unknown sources were responsible. The ratios of fecal streptococcus to fecal coliforms would indicate non-human sources.

B. 1975 Intensive Study

Appendix VI illustrates the water quality data collected during the 1975 "intensive" study.

In general, the water quality during the 1975 survey was similar to that found during the 1974 survey. Levels of dissolved oxygen and BOD_5, with the exception of dissolved oxygen in the Kleinburg S.T.P. effluent, were excellent, with favourably small diurnal-nocturnal fluctuations.

Levels of phosphorus were somewhat lower than for the 1974 survey; similar to the 1974 survey, the 1975 data revealed a phosphorus increase at Kleinburg, with an average level of 0.06 mg/l upstream (station 6) to an average level of 0.09 downstream (station 8) of the treatment plant. The bacteria data collected in the 1975 survey indicated that the bacteria counts likely exceeded the Ministry's body contact recreational criteria, with an indication that unidentified, non-human sources were responsible.

C. Water Quality Monitoring Program - 1975

Appendix VII illustrates the data collected during the three monitoring runs (June 5, July 10, August 7) at the 15 sampling locations (Figure 1). In general, these data verified the excellent water quality that was found during the 1974 and 1975 "intensive" surveys.

D. Water Quality Monitoring Program - Pre 1975

There are three "long term" water quality monitoring stations located on the Upper Humber System (see Figure 1) pertinent to the present study:

a) Station 06-0083-005-02, Humber River below Bolton S.T.P. outfall

b) Station 06-0083-004-02, East Humber River just upstream from the confluence of this River with the Humber River

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c) Station 06-0083-003-02, Humber River below the confluence with the East Humber River.

Data from these monitoring stations (1972-1974) were reviewed as part of the present assessment. These data are on file at the Central Region of the Ministry of the Environment. In general, the data reveal fairly good water quality at all three stations.

Recent provisional 1975 data were reviewed to assess any changes in the water quality of the rivers at the monitoring stations. Similar results as the ones in 1973 and 1974 reveal consistant water quality in the rivers.

Table 1 illustrates water quality comparisons between the three monitoring stations. It is evident there are two basic differences between the East Humber River and the Humber River:

1) the East Humber River has a higher mineral content, indicated by the higher conductivity, dissolved solids and chloride

2) the Humber River has a higher concentration of nutrients, organics and coliform bacteria.

The dissimilarity in mineral content probably is a reflection of differences in the geology and soils of the two sub-basins. The differences in nutrients, organic content and bacteria are likely related to the greater human population and activity on the Humber River with the accompanying watershed disruption, including the effluent discharges at Bolton and Kleinburg.

DISCUSSION OF ACCEPTABLE WASTE LOADINGS

The policy of the Ministry, which was adopted before 1973, has been to restrict further expansion of upstream plants on the Humber River; also, no new effluent producing sewage treatment plants were to be allowed in the Regional Municipality of York. The methods of sewage treatment in general

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Table 1. Water Quality Characteristics (mediun values) at the Three Long-Term Monitoring Stations (1972-74)

Parameter	06-0083-005-02 Humber River at Bolton	06-0083-004-02 East Humber River at Woodbridge	06-0083-003-02 Humber River below Confluence with East Humber River
TOTAL COLIFORMS /100 ML	588	492	1600
FECAL COLIFORMS /100 ML	130	53	126
FECAL STREPTOCOCCUS /100 ML	91	52	60
BOD_5 (mg/l)	1.3	1.2	1.4
TOTAL P (mg/l)	.082	.031	.062
SOL. P (mg/l)	0.041	0.004	0.016
TOTAL N (mg/l)	1.058	0.573	.935
CONDUCTIVITY umhos/cm^3	468	615	538
CHLORIDE (mg/l)	18	38	26

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use at that time included conventional secondary treatment, of the activated sludge type, and sewage lagoons with seasonal or continuous discharge. As a result of the extent of development permitted in upstream areas and the limited flows available to assimilate sewage effluents from any sizeable development area, problems developed from using conventional treatment systems which the Ministry of the Environment is presently attempting to overcome with the Central York Servicing Scheme.

Since then, more advanced treatment methods have been implemented using conventional secondary treatment with phosphorus removal and effluent filtration. In some instances, flow equalization and storm holding tanks to equalize flows and reduce the possibility of bypass during periods of heavy flow have been provided. With the above tertiary treatment systems in general use today, higher quality effluents are being consistently achieved than once felt practicable. Therefore, from a sewage servicing standpoint it is considered that, because of the proven methods of advanced treatment that have been established, additional development could be allowed on the Upper Humber River without affecting downstream uses.

It is felt that a minimum level of treatment should be specified for new plants and further expansions of existing upstream plants in the Regional Municipality of York and Peel, that will provide the greatest protection for the Humber River and preclude future problems with stream quality. For continuous discharge, the minimum level of treatment should include conventional secondary treatment with phosphorus removal and effluent filtration. While this type of treatment facility should generally produce at BOD_5 level of 7.5 mg/l, periodic operational problems will no doubt result in the effluent sometimes exceeding this level. Hence, for purposes of this report, an effluent BOD_5 level of 10 mg/l was used in calculating loading to the streams.

Similarly for seasonal discharges the minimum level of treatment should include chemical treatment to maximize the

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removal of phosphorus and organics. Before increased urbanization does take place in the upstream or other sensitive areas, assurance should be given by the municipalities concerned that storm water can be controlled in quality and quantity and that the possibility of by-pass during periods of heavy flow will be minimized.

Regarding the waste carrying capacity of the Humber River, the hydrologic information presented earlier for the Elder Mills gauge can be used without adjustment, to indicate available dilution at Kleinburg, since the recording gauge is very near the S.T.P. discharge. For Bolton, however, the Cedar Mills gauge is located upstream of the discharge and measures the flow of a 65 square mile drainage basin. Since Bolton is about 77 square miles, the following flows at the Bolton S.T.P. outfall location were pro-rated based on the information from the Cedar Mills gauge.

Pro-Rated Low Flow Characteristics, For Humber River At Bolton, For Selected Recurrence Intervals

Minimum Annual Seven-Day Flows at Selected Recurrence Intervals

Most Probable		5-Year		10-Year		20-Year	
cfs	mgd	cfs	mgd	cfs	mgd	cfs	mgd
33.2	17.9	14.8	7.99	12.1	6.53	10.0	5.40

The following discussion outlines the waste carrying capacity of the Humber River, based on the assumption that waste treatment facilities will include those outlined in the previous discussion, and based on the standard design criterium of $7Q_{20}$ flow conditions.

Organic Loading (BOD)

As a full mathematical wastewater assimilation study of the Humber River was not carried out, an acceptable level of organic material expressed in BOD_5 in the River was conservatively estimated based on experience within this Ministry and knowledge of streams in a similar physiographic setting.

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A permissible stream BOD_5 level of 4 mg/l has been used by this Ministry and was considered applicable to the Humber River downstream of the proposed Nashville Reservoir location and to the East Humber until such time when a more detailed and intensive study would indicate otherwise. As this proposed reservoir would likely support heavy recreational usage due to its proximity to Metro Toronto and would result in a greater degree of oxygen deficiency due to stagnation and plant respiration, it is recommended that a BOD_5 level of 3 mg/l be used for the waters feeding the proposed Nashville Reservoir. In calculating the permissible waste loadings relating to these permissible stream BOD's, some "reserve" capacity must be retained in the stream for organic loadings from accidental spills, general urban impact (other than S.T.P. discharge), and other sources which are impossible to quantify. Hence, one third of the assimilative capacity must be preserved.

Bolton

Existing data reveal that with the existing low flow regime of the Humber River at Bolton, and with the existing population and sewage treatment facilities, there is no problem with respect to the organic loadings to the River. Concentrations of BOD_5 in the River are favourably low, and levels of dissolved oxygen remain near saturation even when the stream flow approaches $7Q_{20}$ conditions (10 cfs). With an average BOD_5 concentration in the River upstream of Bolton of 0.9 mg/l (existing) and a low flow of 10 cfs, the stream could assimilate a sewage effluent loading of 110 lb. BOD_5/day. This loading which retains one third of the stream capacity for reasons previously outlined, equates to an S.T.P. hydraulic volume of 1.1 MIGD, which would provide for a population of 11,000 people assuming an average discharge of 100 imperial gallons per person per day (IGPCD). All of the above assumes that the BOD_5 of the final effluent would be 10 mg/l.

Kleinburg

With respect of Kleinburg, there is similarly no organic dissolved oxygen problem in the River under existing conditions.

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In the calculations relating to the possibility of future waste loading restrictions, an upstream BOD_5 value of 2 mg/l was used. Based on the premise that waste discharges from the Kleinburg area could increase the BOD_5 of the stream from 2 mg/l to 4 mg/l, the stream could assimilate a sewage effluent of approximately 210 lb. BOD_5/day. This equates to a hydraulic S.T.P. volume of 2.1 MIGD (21,000 people at 100 IGPCD). All of this is based on an upstream flow of 18.0 cfs which is the estimated $7Q_{20}$ for the Humber River at Kleinburg, an S.T.P. effluent BOD_5 of 10 mg/l, and a retention of one third of the stream capacity.

Nobleton

With respect to a possible treated sewage discharge from Nobleton, the East Humber would be the most economical waste receiver due to its proximity. Because of the low summer flows in the East Humber ($7Q_{20}$ of 1-2 cfs - see Appendix IV), a continuous discharge would not be acceptable. Alternately, for a seasonal discharge to the East Humber, the $7Q_{20}$ flows available for dilution are estimated at only 4.7 cfs in the spring period (April-May) and 1.8 cfs during the fall period (October-November). While a fall discharge would not be acceptable because of the low stream flows, a spring discharge could be considered. It is suggested that the receiving stream should provide for at least a 3:1 dilution of the effluent (assuming BOD_5 of 15 mg/l in effluent). Although a much greater dilution is normally required on a year round basis because of the critical summer months, it is suggested that 3:1 would be environmentally acceptable when temperatures are low with a corresponding low rate of biochemical oxygen demand. Using this 3:1 criteria and assuming a 30-day discharge period, the total lagoon volume that could be discharged would be 26 MG, which is equivalent to the sewage volume from less than 1000 people (assuming 100 gallons per person per day). It therefore would appear that this is not a realistic alternative, and that the Humber River would have to be used as the "waste receiver".

The following discussion relates to the feasibility of a continuous discharge system compared to a seasonal discharge

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to the main Humber River.

Continuous Discharge - Because of the possibility of future enrichment in the proposed Nashville Reservoir, any discharge from the Nobleton area should enter the Humber River below the Reservoir. It would also appear from the preceeding discussion that the Humber River near Kleinburg could adequately assimilate additional treated sewage from the Kleinburg and Nobleton areas, since the present loading is far below the capacity of the River.

Seasonal Discharge - Considering a seasonal discharge retention facility for Nobleton, with spring and fall discharge, it is suggested that the receiving stream should provide for at least a 3:1 dilution of the effluent (assuming BOD_5 of 15 mg/l in effluent). A hydrological interpretation of Figure 2 would suggest that the $7Q_{20}$ during the fall is 20 - 25 cfs. Hence, the effluent should not exceed 7 - 8 cfs. Relating this criteria to Nobleton, it should be noted that for 8000 people with a waste volume of 100 imperial gallons per person per day, the semi-annual accumulation of waste would be 146 million imperial gallons. This volume, discharged sequentially over 30 days, would result in a flow of approximately 9 cfs. Therefore, it appears that a seasonal retention system could be considered.

Phosphorus and Nitrogen

Existing data reveal that with respect to phosphorus, the concentrations in the Humber River in general are equal to or exceed the "critical" level of 60 ug/l (2) defined by the Ministry of the Environment as the minimum level which causes the maximum growth of the alga Cladophora.

With further urban development on the watershed, phosphorus levels will likely continue to exceed this "critical" level. It is surprising that the present field studies provided no evidence of excessive production of Cladophora; the apparent lack of this alga may be a result of unsuitable substrate conditions. However, it should be kept in mind that aquatic

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plant problems could substantially increase if nutrient concentrations were allowed to increase, particularly in places such as the proposed Nashville Reservoir which will provide an ideal environment for aquatic plant production. The need is apparent for a high degree of waste treatment to produce a maximum phosphorus level of 0.5 mg/l in new effluent discharges.

Unlike the Humber River, the phosphorus levels in the East Humber are too low at present to stimulate nuisance growths of Cladophora.

Regarding nitrogen, it would appear that the concentration of nitrate in the River is of greatest potential concern, as this is a stable compound which can impair health when greater than 10 mg/l as N levels are consumed. Existing nitrate levels are low and entirely satisfactory. Therefore, in terms of the nitrogenous wastes discharged from sewage treatment facilities, the nitrogenous loadings should be regulated in such a manner to ensure that the River waters do not exceed 7.5 mg/l as N under $7Q_{20}$ flow conditions. Since Kjeldahl nitrogen, nitrite and ammonia all oxidize to the more stable nitrate form either in a treatment system or in the receiving waters, the 7.5 mg/l criteria for the Humber River refers to the "nitrogen equivalent" and includes Kjeldahl, nitrite, nitrate and ammonia. Calculations reveal that with a treatment plant at Bolton supplying a BOD_5 of 10 mg/l and a nitrogen equivalent of 20 mg/l (as N), the organic (i.e. BOD) assimilative capacity of the River below Bolton would be reached before reaching the nitrate "assimilative capacity"; in order to maintain a downstream nitrate of 7.5 mg/l, the S.T.P. would theoretically be limited to a hydraulic loading of approximately 3.2 MIGD.

Regarding the limitations with respect to nitrate discharges from Kleinburg (plus possibly Nobleton in future), this is impossible to accurately assess at present since the future nitrate level remaining in the River, as a result of future urbanization at Bolton, cannot be predicted. If, however, it is assumed that all of the nitrate discharged from Bolton was assimilated into River biota before the River reached Kleinburg, then it is estimated that the maximum Kleinburg-

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Nobleton S.T.P. discharge would theoretically be 5.8 MIGD, which is not nearly as restrictive is the limitation set by the BOD_5 loading. However, it is likely that the nitrates from Bolton would not be fully assimilated at Kleinburg. It is felt that growth restrictions with respect to nitrate loadings, or the need for nitrogen removal, would not materialize until the treated sewage discharges in the Kleinburg area served a population of perhaps 20,000 to 30,000 people, which is comparable to the loading limits set by BOD.

Bacteria

As pointed out earlier, the bacterial levels in the study area likely would not meet the body-contact recreational criteria of the Ministry. However, it is expected that the levels only marginally exceed the criteria and should not pose a health hazard. Since the bacterial levels are mostly from non-point and likely non-human waste sources, it is probable that the Humber River will continue to be only marginally acceptable for body contact recreation. It should be pointed out, however, that increased urban development with untreated storm water would likely aggravate the existing bacterial problem, especially during rainy periods.

Chlorine

Concern about chlorine toxicity arises from the facts that chlorinated S.T.P. effluents enter the Humber River both at Bolton and Kleinburg.

Regarding the "safe" level of residual chlorine in a stream, literature data varies greatly. Brungs (3), having recently reviewed 126 papers on the subject, states that "In areas receiving wastes treated continuously with chlorine, total residual chlorine should not exceed 0.01 mg/l for the protection of more resistant organisms only, or exceed 0.002 mg/l for the protection of most aquatic organisms". This information, related to the biological character of the stream, would suggest that the River levels should not exceed 0.01 mg/l total residual chlorine. This would mean

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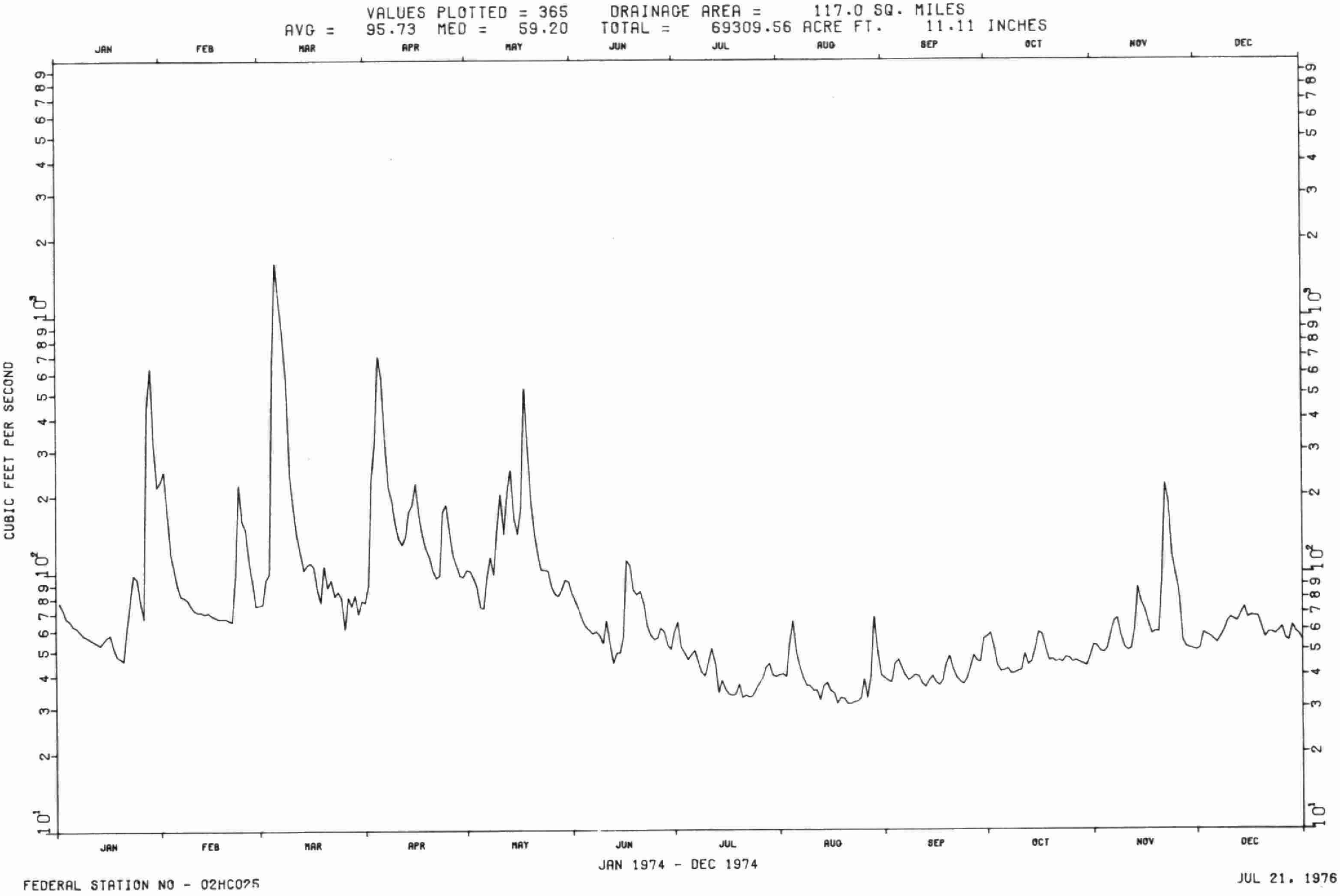
for example, that with the Bolton S.T.P. operating at a hydraulic volume of 1.0 MIGD, and with a $7Q_{20}$ flow of 10 cfs, the concentration of total residual chlorine in the effluent should not exceed 0.06 mg/l. Since this concentration may not provide for adequate disinfection, a dechlorination system, or another method of disinfection, may be required.

REFERENCES

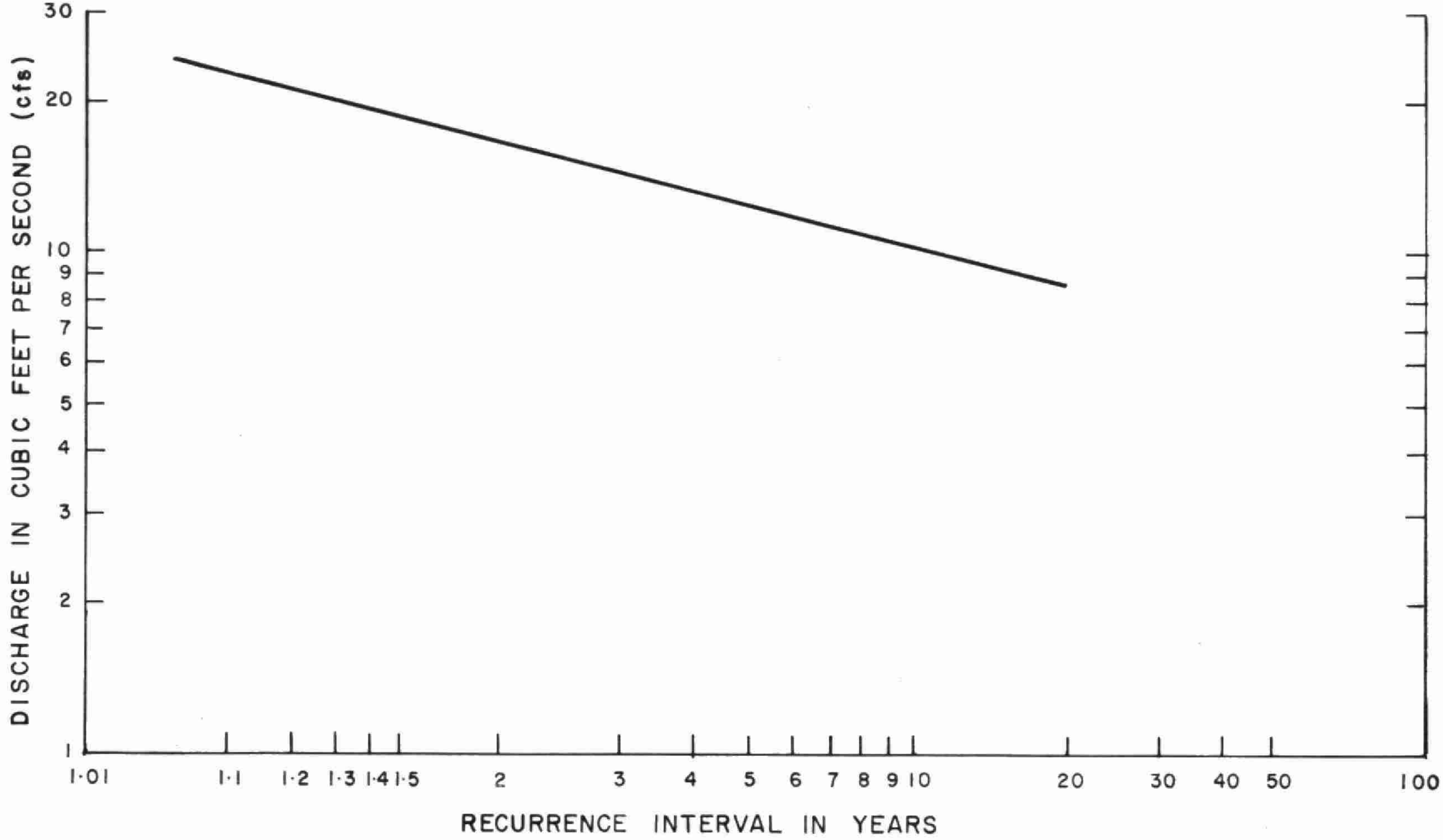
1) Regional Municipality of York Rural Communities Services Study, Underwood, McLellan & Associates Limited (The UMA Group), September, 1974.

2) Field Determination of the Critical Nutrient Concentrations for *Cladophora* in streams and their Importance in Waste Load Management - Report of the Water Resources Branch, Ontario Ministry of the Environment.

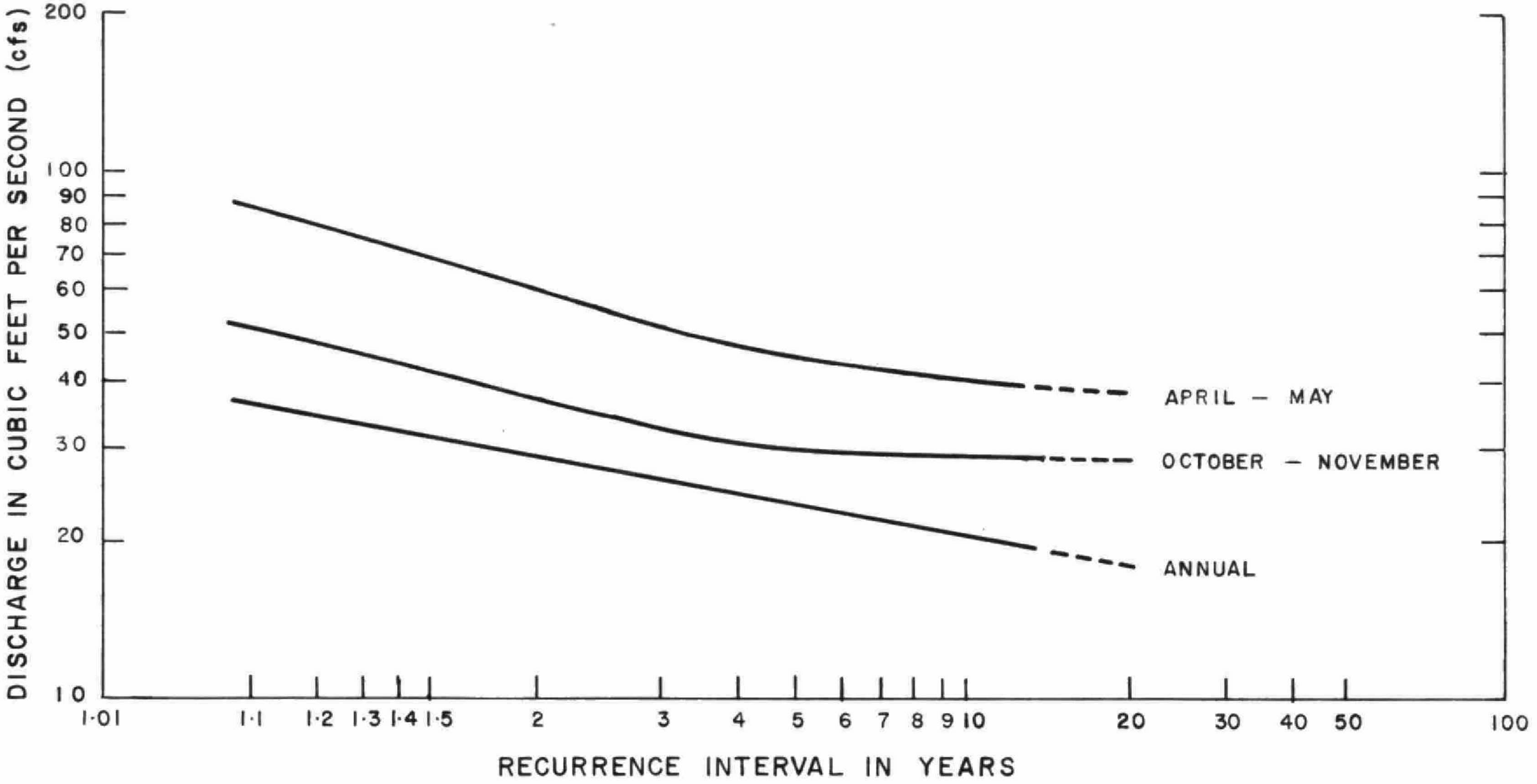
3. Effects of Residual Chlorine on Aquatic Life -W.A. Brungs - Journal WPCF, V.45 No. 10, October 1973.



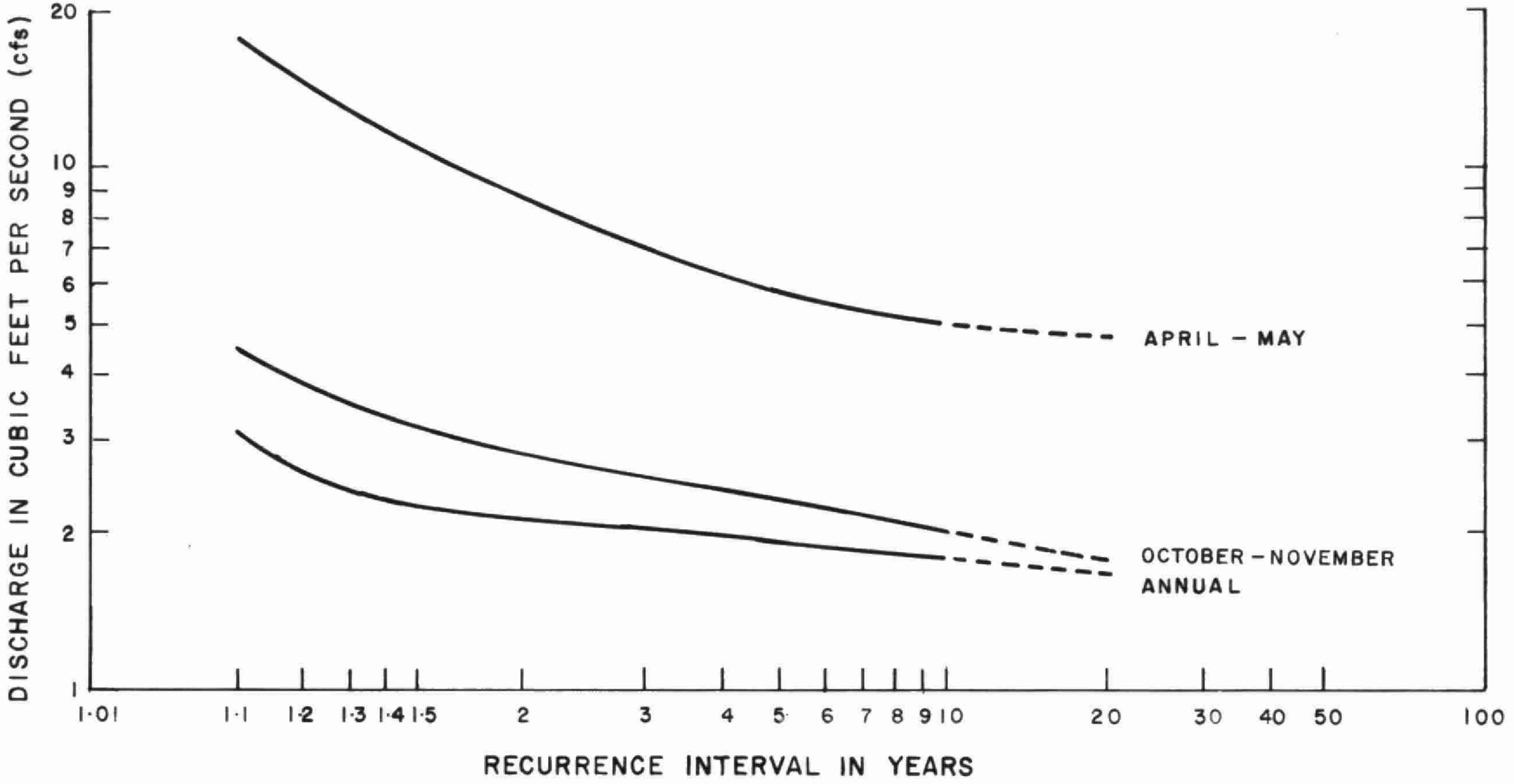
APPENDIX 1 - TYPICAL ANNUAL HYDROGRAPH OF THE HUMBER RIVER AT ELDER MILLS GAUGE



APPENDIX II: FREQUENCY CURVE OF ANNUAL MINIMUM STREAM FLOWS AVERAGED OVER SEVEN CONSECUTIVE DAYS FOR THE HUMBER RIVER AT CEDER MILLS (STATION 02HC012); PERIOD OF RECORD: 1957 — 1973



APPENDIX III : FREQUENCY CURVES OF MINIMUM DISCHARGES AVERAGED OVER SEVEN CONSECUTIVE DAYS FOR THE INDICATED PERIODS : HUMBER RIVER AT ELDER MILLS (02HC025); PERIOD OF RECORD : 1962 — 1974



APPENDIX IV : FREQUENCY CURVES OF MINIMUM DISCHARGES AVERAGED OVER SEVEN CONSECUTIVE DAYS FOR THE INDICATED PERIODS, EAST HUMBER RIVER AT HUMBER TRAILS (02HC032) PERIOD OF RECORD : 1965 – 1974

Appendix V

Data obtained during the June 24-25, 1974 study. Unless otherwise indicated, numbers refer to average values.

	Dissolved Oxygen/MG/l)			Temp.	BOD (mg/l)			Bacteria/100ml. (Geometric Mean)			Phosphorus	
Station	Mean	Max.	Min.	°C	Mean	Max.	Min.	Total	Fecal	Strep	Tol.	Sol.
1	9.2	10.1	8.5	16.5	1.0	1.4	0.6	1090	13	36	0.049	0.004
2 (STP)	8.1	8.5	7.6	14.6	4.6	6	3	79	22	22	0.30	0.046
3	9.0	10.0	8.5	17.4	1.2	1.4	0.8	3990	100	126	0.11	0.013
12	9.6	11.4	8.5	14.5	0.5	0.6	0.4	664	103	150	0.042	0.011
4	9.3	10.4	8.7	17.2	1.0	1.2	0.8	2738	100	60	0.068	0.004
5	8.7	9.8	8.2	17.8	1.1	1.4	1.0	2000	128	156	0.088	0.006
6	9.0	9.7	8.5	18.3	1.2	1.4	1.2	1567	159	106	0.098	0.005
7 (STP)	2.8	4.1	2.0	16.2	8.5	12	6.5	172	53	100	6.4	5.7
8	9.4	10.2	8.4	18.2	1.3	1.4	1.2	1787	126	89	0.18	0.044
9	9.5	9.8	8.6	18.2	1.4	1.6	1.2	7000	374	775	0.14	0.021
10	9.2	9.8	8.3	18.4	1.4	1.8	1.2	3674	144	363	0.14	0.014
11	9.1	9.5	8.8	18.4	1.4	1.6	1.2	2106	182	122	0.11	0.011

Appendix V (continued)

	Nitrogen			Turbidity	Chloride	Conductivity	Total Solids
F.A.	Kjel.	Nitrite	Nitrate	F.T.U.	mg/l	umhos/cm^3	mg/l
0.01	0.45	0.008	0.30	6.7	16	439	
2.6	4.0	0.039	19	3.0	178	1242	730
0.046	0.59	0.012	0.65	8.3	18	453	450
0.01	0.32	0.009	0.17	4.6	5.4	466	
0.03	0.54	0.011	0.44	13.5	15	444	
0.02	0.50	0.011	0.41	17	16	455	
0.01	0.55	0.012	0.35	21	16	456	
2.3	6.2	0.38	22	7.9	215	1384	758
0.02	0.63	0.016	0.42	27	20	474	423
0.01	0.60	0.012	0.37	31	20	457	
0.01	0.61	0.013	0.32	40	20	453	
0.01	0.56	0.013	0.29	29	20	454	

APPENDIX VI

DATA OBTAINED DURING THE AUGUST 12-13, 1975 STUDY

UNLESS OTHERWISE INDICATED, NUMBERS REFER TO AVERAGE VALUES

STATION	DISSOLVED OXYGEN (MG/L)			TEMP.	BOD5 (MG/L)			BACTERIA/100ml			PHOSPHORUS (MG/L)		NITROGEN as N (MG/L)				SOLIDS (MG/L)		CHLORIDE	CONDUCTIVITY
	MEAN	MAX.	MIN.	°C	MEAN	MAX.	MIN.	TOTAL	FECAL	STREP.	TOTAL	SOL.	F.A.	KJEL.	NITRITE	NITRATE	TOT.	SUSP.	(MG/L)	umhos/cm³
1	9.3	10.9	7.8	23.9	0.9	1.0	0.8	320	80	60	0.025	0.013	0.05	0.44	0.003	0.01			14	385
15	8.8	8.9	8.6	23.9	0.8	1.0	0.6	740	<100	<100	0.045	0.011	0.04	0.50	0.003	0.10			15	378
2-STP	7.8	8.6	7.3	20.3	1.6	2.0	1.2	<1000	<100	<1000	0.41	0.24	0.13	0.97	0.046	20.0	520	11	155	730
12-TRIB.	10.4	11.8	9.4	17.5	0.7	0.8	0.6	400	<100	140	0.051	0.017	0.04	0.43	0.006	0.57	259	17	18	410
3	9.2	10.8	8.3	23.3	0.5	0.6	0.4	2090	<100	100	0.027	0.007	0.02	0.22	0.005	0.11			6.2	450
4	9.8	13.7	8.1	22.9	0.8	1.2	0.4	650	80	50	0.034	0.009	0.03	0.26	0.005	0.22			15	403
5	9.2	10.8	7.8	23.3	0.6	0.6	0.6	540	310	190	0.067	0.012	0.03	0.42	0.009	0.20			16	393
6	9.5	11.8	7.8	23.8	0.8	1.0	0.6	160	40	50	0.059	0.006	0.02	0.35	0.004	0.04			16	385
7-STP	2.1	3.1	0.6	20.4	2.2	2.4	2.0	<210	<150	<170	4.3	4.1	6.6	8.9	0.253	4.6	490	8	236	928
8	9.2	11.0	7.9	23.8	0.8	1.0	0.6	700	200	70	0.091	0.030	0.05	0.40	0.007	<0.01	292	32	17	400
9	9.0	10.7	8.1	24.1	0.7	0.8	0.6	640	90	90	0.088	0.021	0.03	0.49	0.003	<0.01			17	380
10	9.0	10.5	8.2	24.4	0.8	1.0	0.6	460	110	50	0.060	0.012	0.01	0.39	0.003	<0.01			17	380
11	9.0	10.6	8.3	24.7	0.8	1.0	0.6	100	20	90	0.060	0.008	0.03	0.58	0.003	<0.01			17	375
13	9.2	11.0	7.7	24.3	0.7	1.0	0.4	910	90	150	0.029	0.004	0.02	0.32	0.004	0.08			26	480
14	8.9	10.4	8.0	24.6	0.6	0.8	0.4	280	140	150	0.074	0.004	0.02	0.49	0.002	<0.01			19	388

APPENDIX III
HUMBER R.

DATA OBTAINED DURING THE 3 "MONITORING" RUNS
AT THE 15 SAMPLING STATIONS ON JUNE-,JULY-AND AUGUST-, 1975.
MONTHLY MONITORING PROGRAM - JUNE-AUGUST 1975
Stations: #1 - #15

UPPER LIMIT IN THE TOWN OF BOLTON
DOWNSTREAM TO HWY.#7 IN THE TOWN
WOODBRIDGE

Stn.	Dissolved Oxygen (mg/l) Mean	Max.	Min.	Temp °C	BOD_5 (mg/l) Mean	Max.	Min.	Bacteria / 100 ml (Geometric Mean) Total	Fecal	Strep.	Phosphorous (mg/l) Total	Sol.	Nitrogen as N (mg/l) F.A.	Kjel.	Nitrite	Nitrate	Solids (mg/l) Tot	Susp	Chloride (mg/l)	Conductivity μmhos/cm³
1	8.9	9.4	8.6	18.9	0.7	1.2	0.6	360	60	90	0.027	0.004	0.02	0.37	0.005	0.17	270	11	14	413
15	9.1	10.7	8.1	19.9	1.5	2.4	1.0	36500	2600	>960	0.060	0.018	0.05	0.52	0.006	<0.13	290	23	16	412
2	6.7	7.1	6.1	17.3	9.3	15.0	2.2	-	-	-	3.2	3.8	10.6	8.0	1.32	8.3	636	22.7	194	910
12	10.1	10.9	9.0	15.0	0.9	1.2	0.6	2340	350	270	0.033	0.014	0.03	0.26	0.012	0.13	290	3.1	5.9	465
3	9.3	10.1	8.6	20.1	1.8	2.0	1.6	35200	1270	1020	0.13	0.078	0.15	0.69	0.098	0.63	280	2.6	19	431
4	9.7	11.2	8.8	19.9	1.4	1.6	1.2	1550	125	143	0.082	0.026	0.05	0.44	0.41	0.25	280	18.3	15	427
5	8.8	8.9	8.6	19.8	1.4	1.6	1.2	> 970	184	190	0.10	0.032	0.07	0.59	0.10	0.40	310	16.8	16	442
6	9.3	11.2	8.4	20.0	1.4	1.4	1.4	500	60	130	0.063	0.009	0.05	0.49	0.025	0.15	290	6.1	16	427
7	2.7	4.3	1.7	18.6	2.6	6.5	0.2	<1000	<20	<20	7.7	5.2	14.3	26	0.314	1.6	751	18.1	307	1700
8	9.8	11.7	8.9	20.7	1.4	1.6	1.2	>1000	210	110	0.083	0.019	<0.05	0.54	0.024	0.13	300	20.0	17	431
9	9.7	11.6	8.3	21.0	1.5	1.8	1.4	>1000	80	<70	0.064	0.015	< 0.06	0.47	0.018	<0.12	300	23.1	18	427
10	9.8	11.4	8.9	21.0	2.6	5.0	1.4	>600	<100	140	0.062	0.008	<0.057	0.61	0.016	<0.14	300	15.6	18	427
11	9.1	9.7	8.3	21.1	1.4	1.6	1.4	270	80	90	0.050	0.003	<0.03	0.52	0.014	<0.10	280	5.7	23	427
13	9.9	11.0	9.4	20.8	1.2	1.4	1.2	1800	200	260	0.015	0.002	<0.01	0.28	0.003	0.05	360	6.3	26	525
14	9.7	11.2	8.4	20.9	1.3	1.8	0.8	520	70	130	0.034	0.003	<0.02	0.38	0.011	<0.09	330	4.0	21.2	435

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